CLAIMS

1. A method for producing multiple quantum well intermixed (QWI) regions having different bandgaps on a single substrate, comprising the steps of:

a) patterning the surface of the substrate with QWI-initiating material in first regions of the surface;

b) conducting a first thermal processing cycle on the substrate to generate a first bandgap shift in the first regions;

c) patterning the surface of the substrate with QWI-initiating material in second regions of the surface, distinct from said first regions; and

d) conducting a second thermal processing cycle on the substrate to generate a second bandgap shift in the second regions, and to generate a cumulative bandgap shift in the first regions, the cumulative bandgap shift being the cumulative result of said first and second thermal processing cycles.

2. The method of claim 1 further including the steps of:

e) patterning the surface of the substrate with QWI-initiating material in third regions of the surface, distinct from said first regions and said second regions; and

f) conducting a third thermal processing cycle on the substrate to: (i) generate a third bandgap shift in the third regions, (ii) generate a cumulative bandgap shift in the second regions, the cumulative bandgap shift in the second regions being the cumulative result of the second and third thermal processing cycles; and (iii) generate a further cumulative bandgap shift in the first regions, the cumulative bandgap shift in the first regions being the cumulative result of the first, second and third thermal processing cycles.

3. The method of claim 2 further including the steps of:

g) patterning the surface of the substrate with QWI-initiating material in other regions of the surface, distinct from all regions of the surface previously covered with QWI-initiating material;

h) conducting a subsequent thermal processing cycle to generate a bandgap shift in the other regions, and to generate cumulative bandgap shifts in all regions previously covered with QWI-initiating material prior to the most recent patterning step, the cumulative bandgap shifts each being the cumulative result of all thermal processing cycles to which the respective region has been exposed since being first covered with the QWI-initiating material.

4. The method of any preceding claim further including the step of covering adjacent regions of the substrate not covered with QWI-initiating material with QWI-inhibiting material.

5. The method of any preceding claim in which at least one of the thermal processing cycles comprises a rapid thermal anneal cycle.

6. The method of claim 5 in which all of the thermal processing cycles comprise rapid thermal anneal cycles.

7. The method of any preceding claim in which the steps of patterning regions of the substrate with QWI-initiating material comprises the steps of:

depositing photoresist on the substrate;

forming windows in the photoresist coextensive with the region of the substrate to be covered with QWI-initiating material;

depositing the QWI-initiating material onto the substrate; and

lifting the photoresist off the substrate.

8. The method of any preceding claim in which the QWI-initiating material comprises an impurity rich material.

9. The method of claim 8 in which the impurity comprises one or more of sulphur, zinc, silicon, fluorine, copper, germanium, tin and selenium.

10. The method of claim 8 or claim 9 in which the impurity-rich material comprises silica doped with one or more of the impurities sulphur, zinc, silicon, fluorine, copper, germanium, tin and selenium.

11. The method of any preceding claim in which the QWI-initiating material is sputter deposited.

12. The method of claim 4 in which the QWI-inhibiting material comprises a PECVD-silica layer.

13. The method of any preceding claim in which the QWI-initiating material from a given region is removed from the substrate after the first thermal processing cycle to which it is exposed and prior to a subsequent thermal processing cycle.

14. The method of any one of claims 1 to 12 in which the QWI-initiating material on a given region is retained on the substrate for subsequent thermal processing cycles.

15. The method of claim 14 in which the QWI-initiating material on a given region is retained on the substrate for all subsequent thermal processing cycles.

16. The method of any preceding claim used on an InP/AlInGaAs substrate.

17. The method of any preceding claim in which each of the thermal processing cycles is performed for substantially the same length of time.

18. The method of claim 17 in which each of the thermal processing cycles is performed at different temperatures.

19. A method for determining required parameters for each of the thermal processing cycles of the method of any preceding claim, comprising the steps of:

determining whether the process for generating cumulative bandgap shifts resulting from successive thermal processing cycles is symmetric or asymmetric;

if the process is symmetric, then determining the thermal process conditions required for each one of a plurality of cumulative bandgap shifts BG_1 to BG_N by successive use of at least one sample through a thermal process sequence A_N to A_1, where A_1 is the thermal process required to obtain BG_N from BG_{N-1}; A_2 is the thermal process required to obtain BG_{N-1} from BG_{N-2}, etc., through to A_N being the thermal process required to obtain BG_1 from BG_0; and

if the process is asymmetric, then determining the thermal process conditions required for each one of the plurality of cumulative bandgap shifts BG_1 to BG_N by use of a plurality of samples through a partial or complete thermal process sequence in the order A_1 to A_N for each one of the bandgap shifts required.

20. The method of claim 19, further comprising the steps of:

(i) establishing thermal processing conditions A_N suitable for obtaining the smallest cumulative bandgap shift BG_1 of the Nth region;

(ii) performing a thermal processing cycle on a first sample using A_N to obtain bandgap shift BG_1;

(iii) establishing thermal processing conditions A_{N-1} suitable for obtaining the cumulative bandgap shift BG_2 of the N−1th region;

(iv) performing a thermal processing cycle on said first sample, after step (ii), using A_{N-1} to obtain bandgap shift BG_2;

(v) performing thermal processing cycles A_{N-1} then A_N on a second sample to obtain bandgap shift BG_2';

(vi) establishing whether the anneal process is symmetric, i.e. if $BG_2 = BG_2'$, and if so performing steps (vii) to (viii), otherwise performing step (ix);

(vii) establishing thermal processing conditions A_{N-2} suitable for obtaining the cumulative bandgap shift BG_3;

(viii) performing a thermal processing cycle on said first sample, after step (iv), using A_{N-2} to obtain bandgap shift BG_3;

(ix) establishing cumulative thermal processing cycles A_1 to A_N for each one of the cumulative bandgap shifts BG_N to BG_1 on separate samples for each one of the cumulative bandgap shifts required.

21. The method of claim 20 further including the steps of:

re-iterating steps (vii) and (viii) in respect of establishing thermal processing conditions suitable for obtaining further cumulative bandgap shifts and in respect of performing thermal processing cycles on the first and subsequent samples in order to complete step (ix) for each one of the cumulative bandgap shifts required.

22. A semiconductor optical device manufactured using the process of any one of claims 1 to 21.

23. A method substantially as described herein with reference to the accompanying drawings.